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Huang

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(54) **TECHNIQUES FOR STEREO THREE DIMENSIONAL IMAGE MAPPING**

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(51) **Int. Cl.**

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G06T 15/00	(2011.01)
G06T 7/00	(2006.01)
G06T 3/40	(2006.01)
H04N 13/00	(2006.01)

(52) **U.S. Cl.**

CPC ***G06T 15/00*** (2013.01); ***G06T 3/403*** (2013.01); ***G06T 7/0085*** (2013.01); ***H04N 13/0022*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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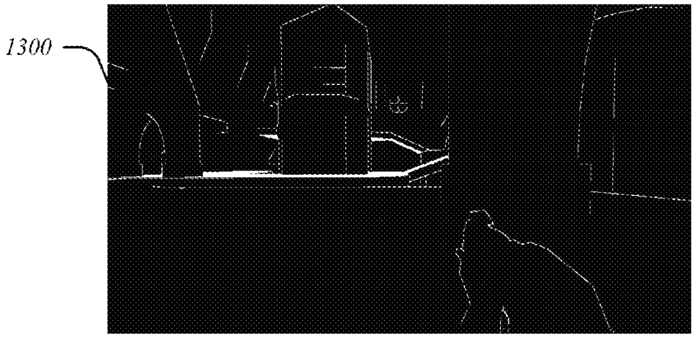
Assistant Examiner — Ryan P Potts

(57) **ABSTRACT**

An apparatus may include processor to retrieve a stereo three dimensional (S3D) frame of an S3D game, the frame comprising a red-green-blue (RGB) frame and depth frame; and an interest aware disparity mapping component to: generate a depth edge frame from the depth frame; and to generate a depth distribution diagram for the depth frame based on the depth edge frame, the depth distribution diagram defining a multiplicity of camera regions for generating a mapped S3D frame for a target device based upon viewing parameters of the target device.

19 Claims, 15 Drawing Sheets



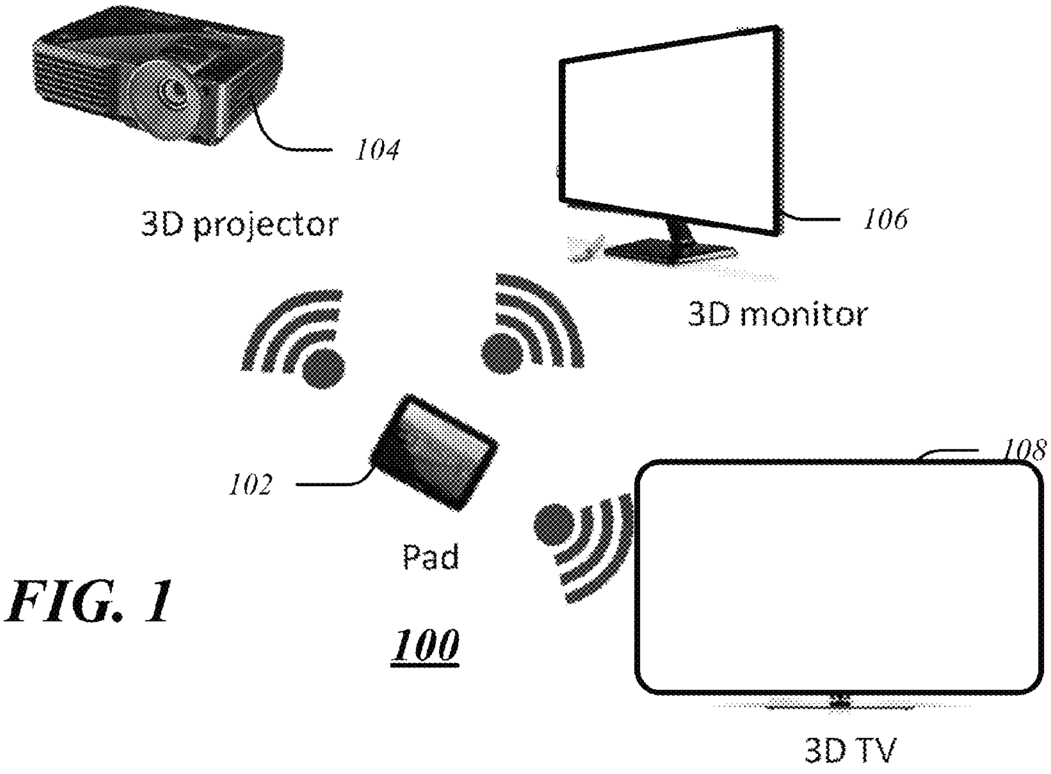
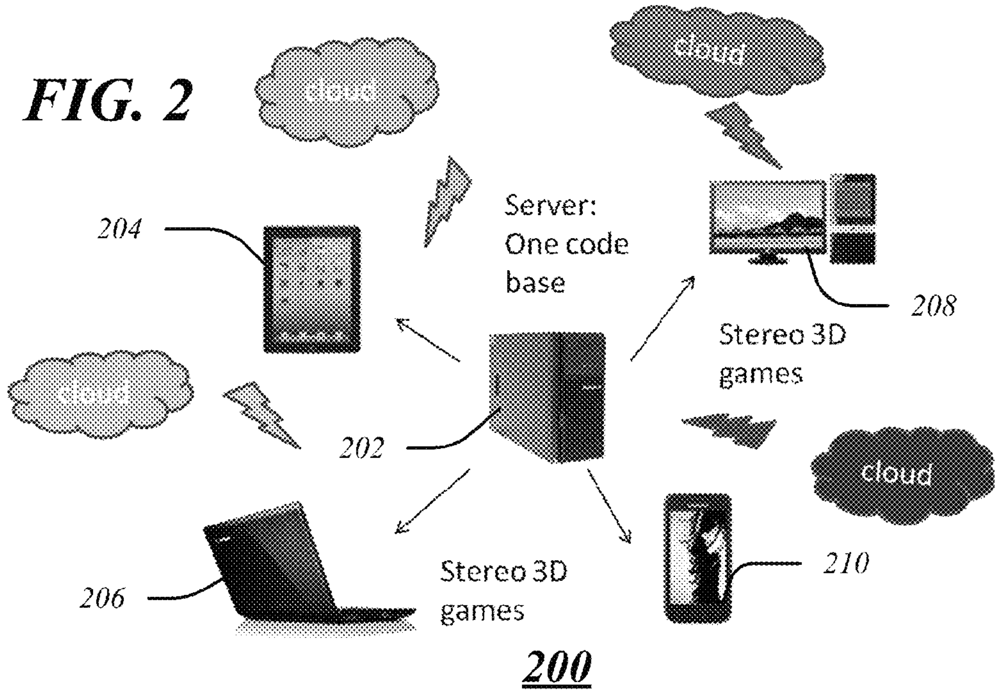

104
3D projector
106
3D monitor
108
102
Pad
100
3D TV

FIG. 1

FIG. 2


cloud
cloud
204
Server:
One code
base
208
Stereo 3D
games
cloud
202
cloud
210
206
Stereo 3D
games
200

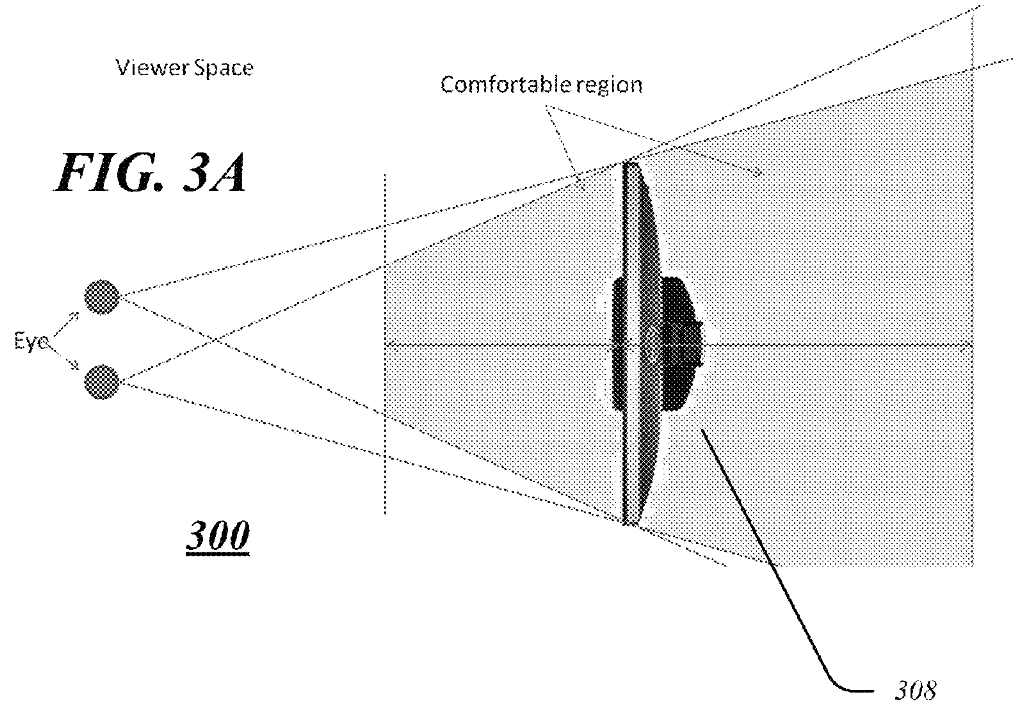


FIG. 3A

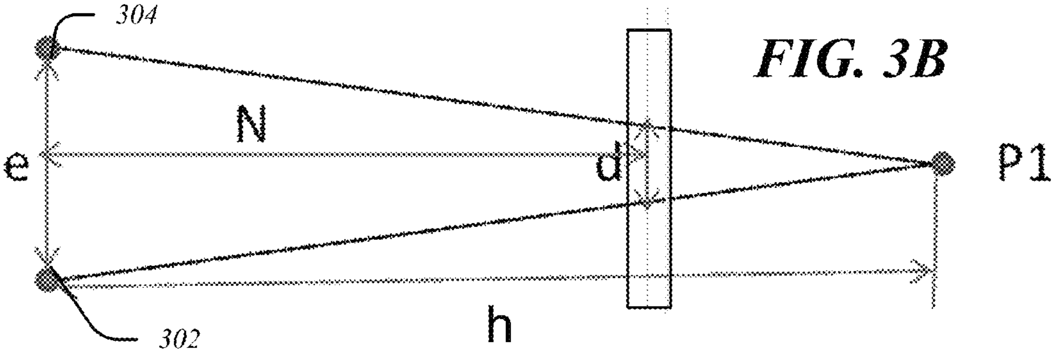


FIG. 3B

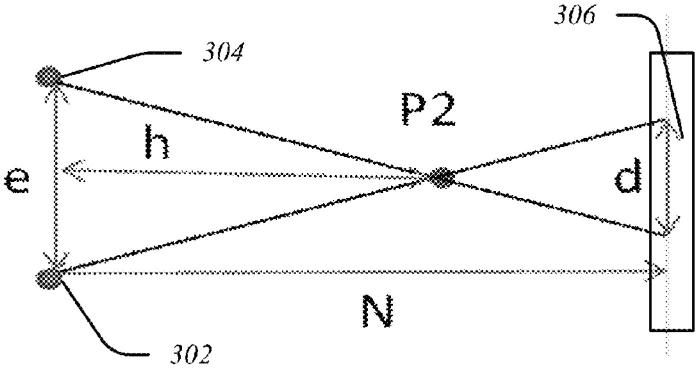


FIG. 3C

FIG. 4

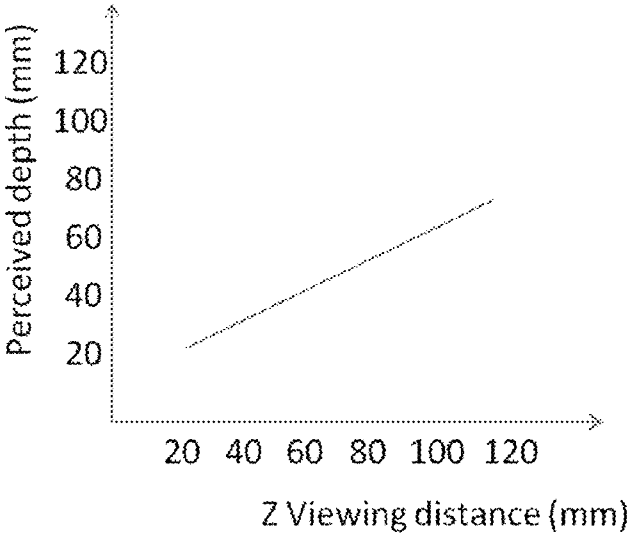


FIG. 5A

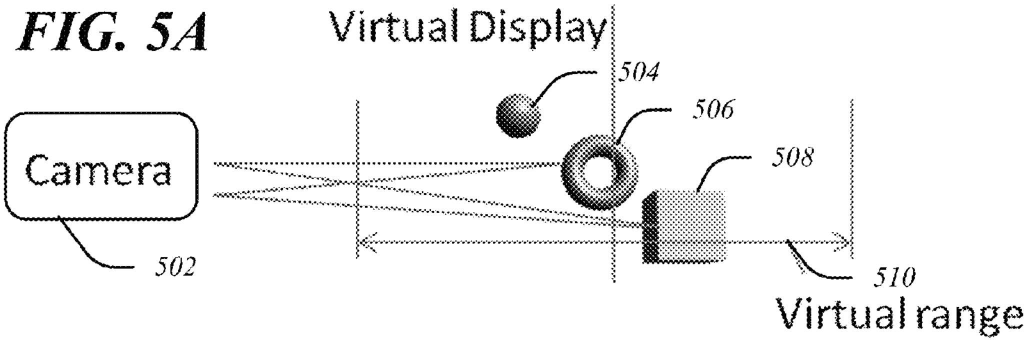
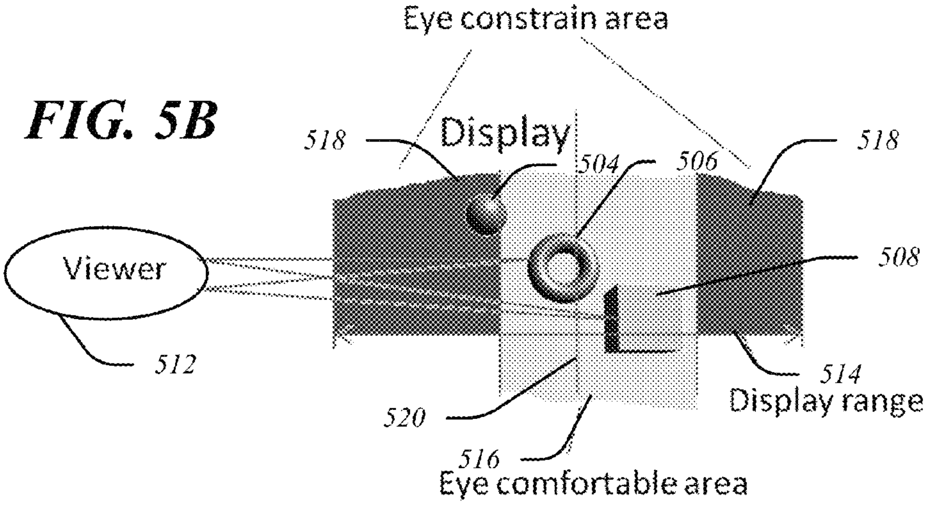


FIG. 5B



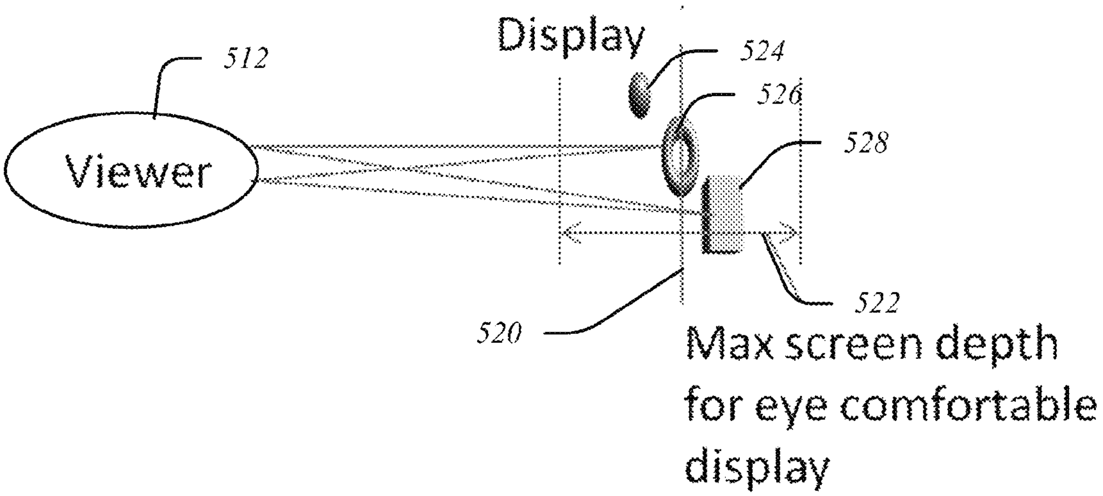

Display
512
524
526
528
Viewer
522
520
Max screen depth
for eye comfortable
display

FIG. 5C

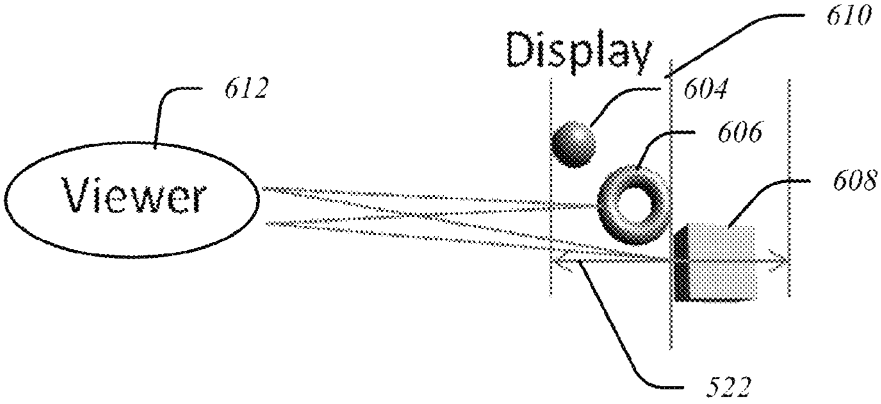

610
Display
612
604
606
608
Viewer
522

FIG. 6

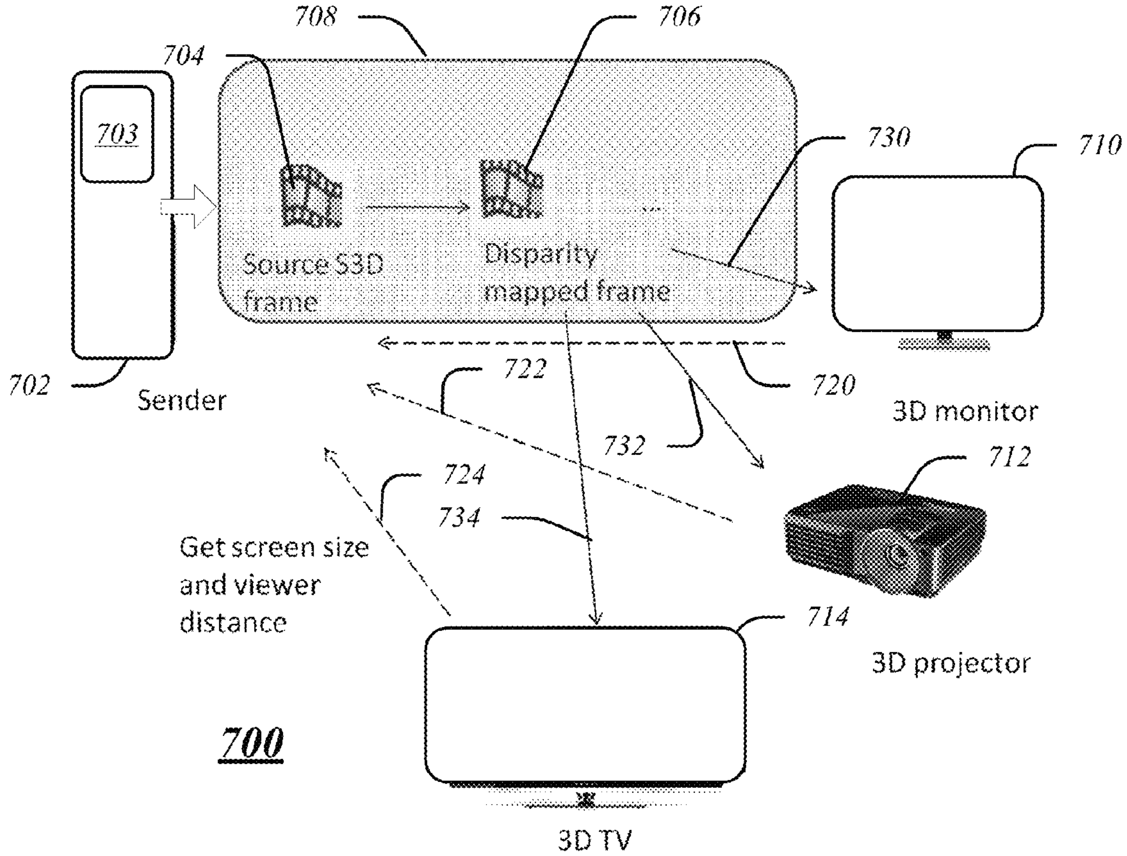

708
706
704
703
730
710
Source S3D frame
Disparity mapped frame
...
702
Sender
722
720
3D monitor
732
712
724
734
Get screen size and viewer distance
714
3D projector
700
3D TV

FIG. 7

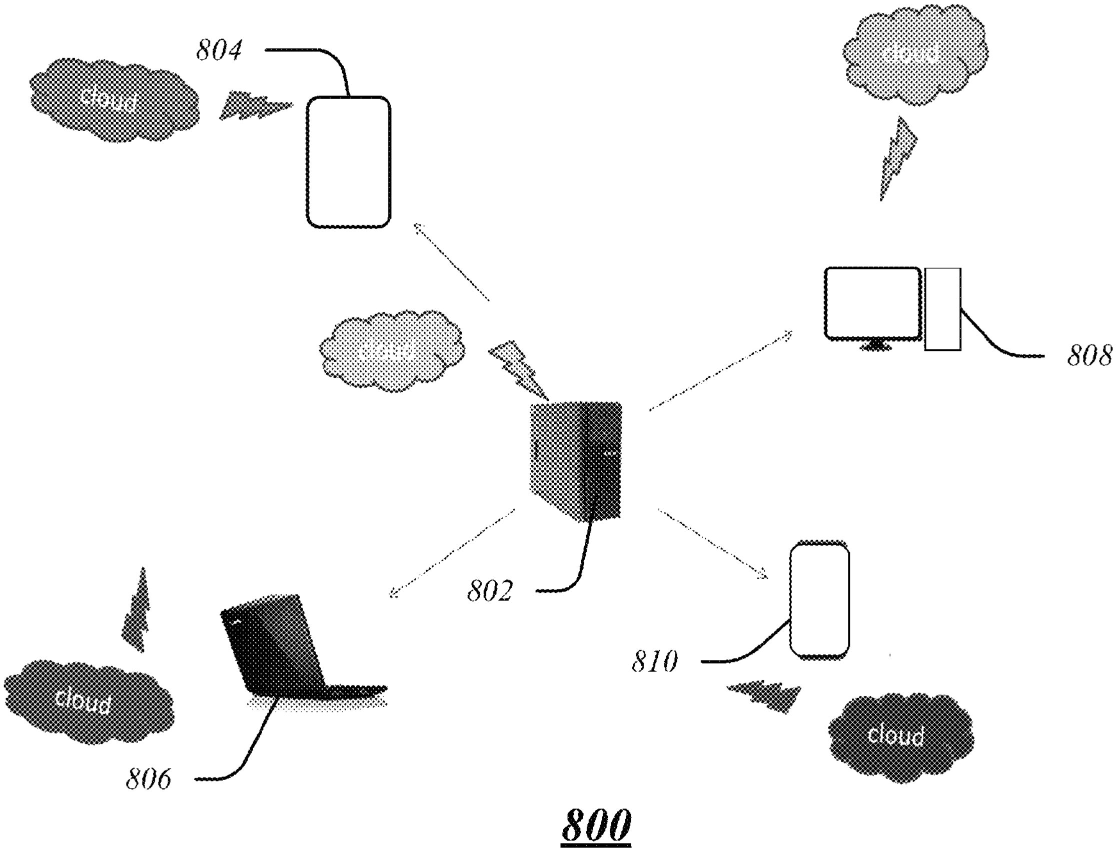


FIG. 8

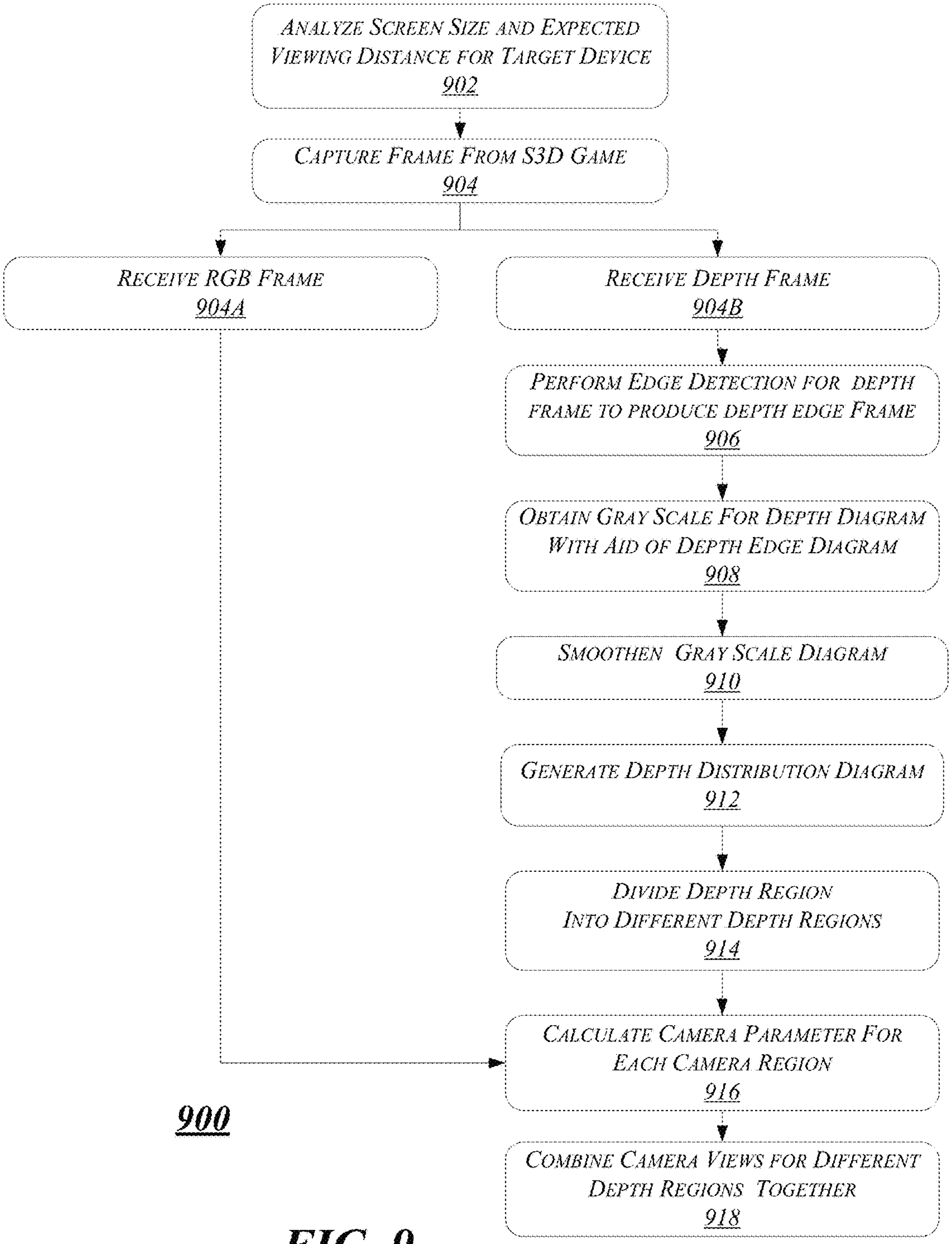

ANALYZE SCREEN SIZE AND EXPECTED VIEWING DISTANCE FOR TARGET DEVICE
902
CAPTURE FRAME FROM S3D GAME
904
RECEIVE RGB FRAME
904A
RECEIVE DEPTH FRAME
904B
PERFORM EDGE DETECTION FOR DEPTH FRAME TO PRODUCE DEPTH EDGE FRAME
906
OBTAIN GRAY SCALE FOR DEPTH DIAGRAM WITH AID OF DEPTH EDGE DIAGRAM
908
SMOOTHEN GRAY SCALE DIAGRAM
910
GENERATE DEPTH DISTRIBUTION DIAGRAM
912
DIVIDE DEPTH REGION INTO DIFFERENT DEPTH REGIONS
914
CALCULATE CAMERA PARAMETER FOR EACH CAMERA REGION
916
COMBINE CAMERA VIEWS FOR DIFFERENT DEPTH REGIONS TOGETHER
918
900

FIG. 9

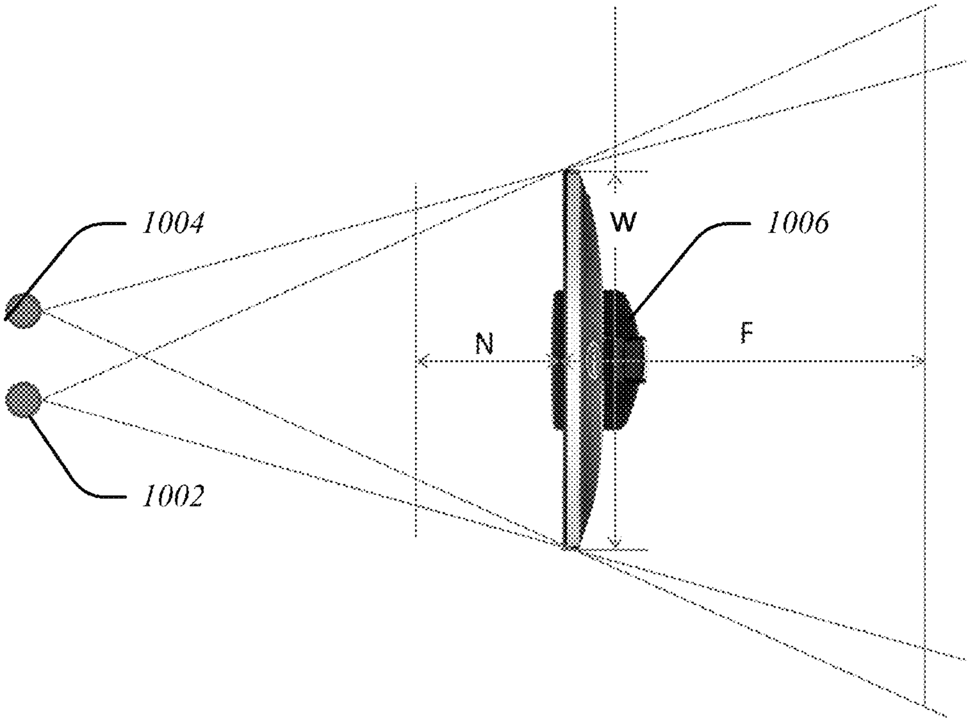


FIG. 10

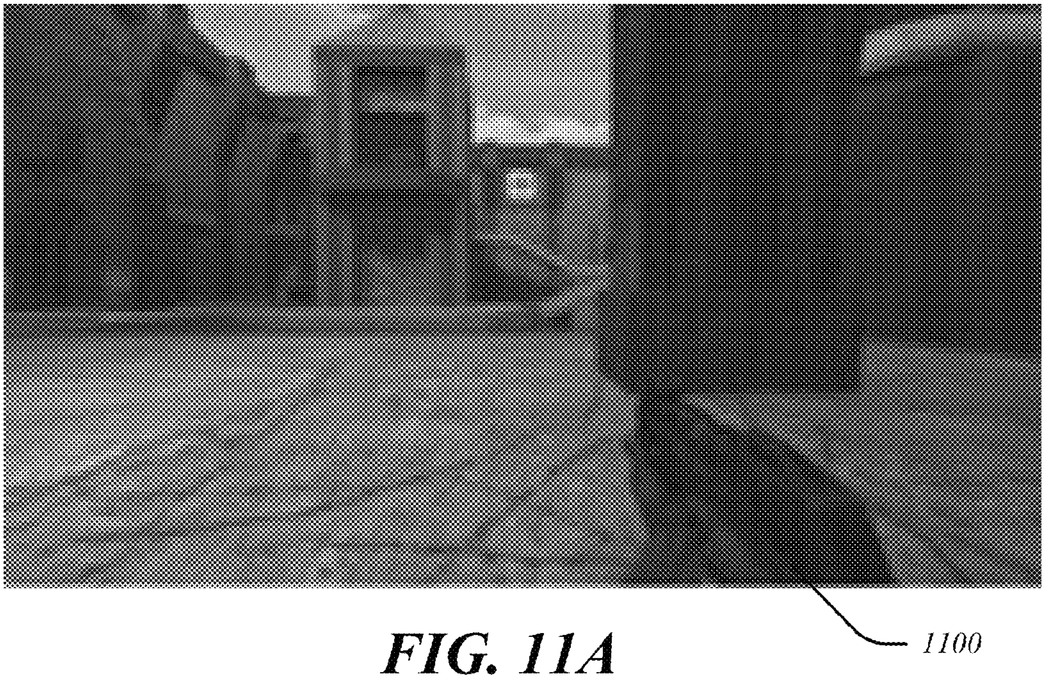


FIG. 11A

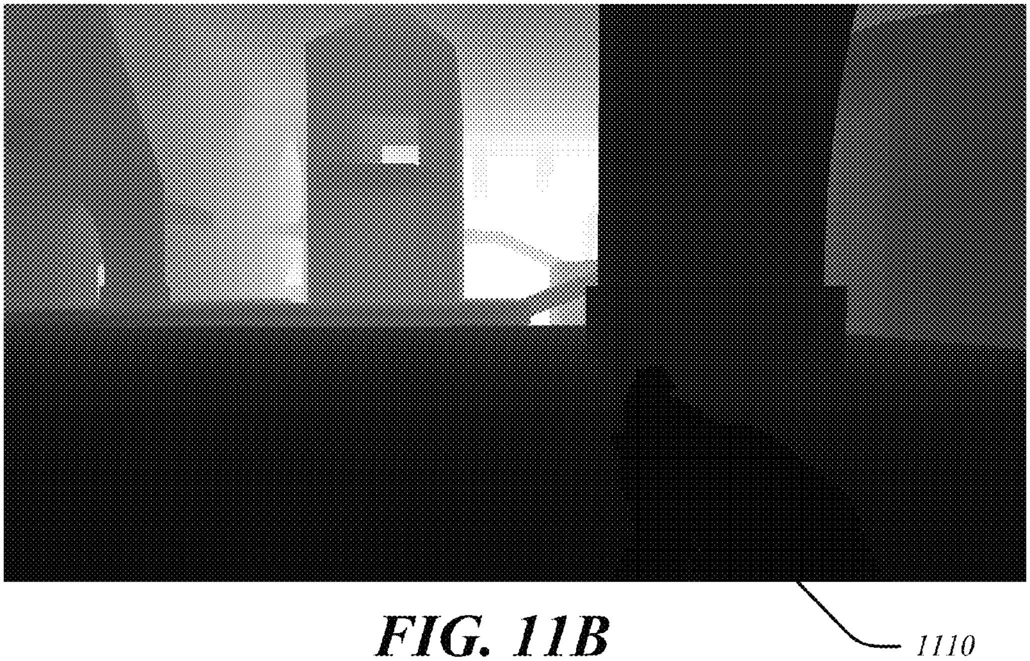


FIG. 11B

FIG. 12A

1202

-1	0	0
0	1	0
0	0	0

FIG. 12B

1204

0	-1	0
1	0	0
0	0	0

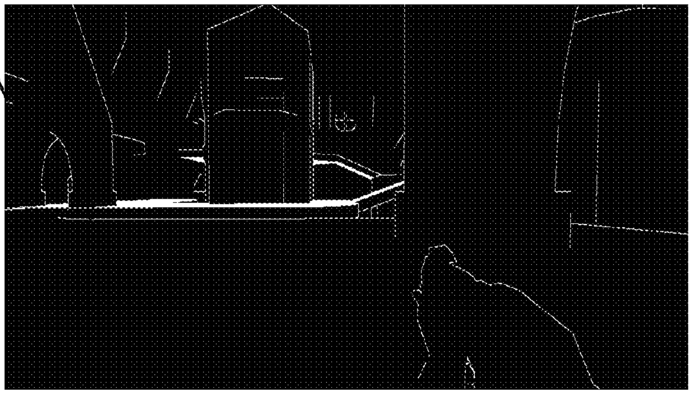


FIG. 13

FIG. 14

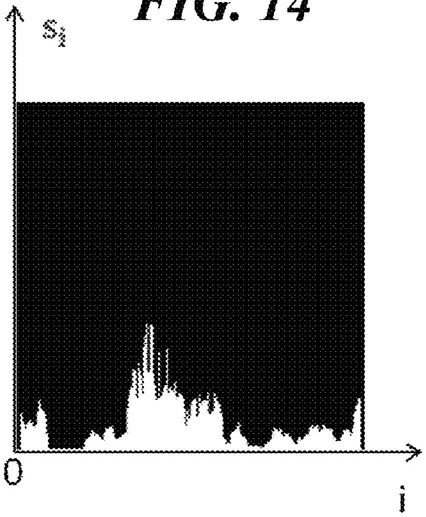
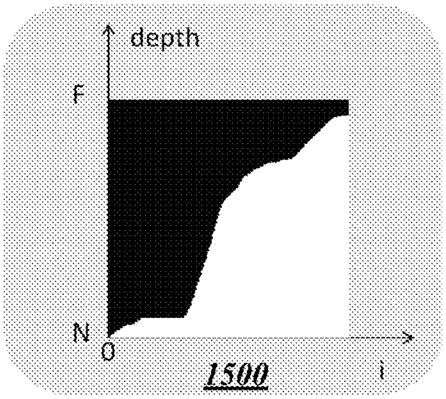


FIG. 15



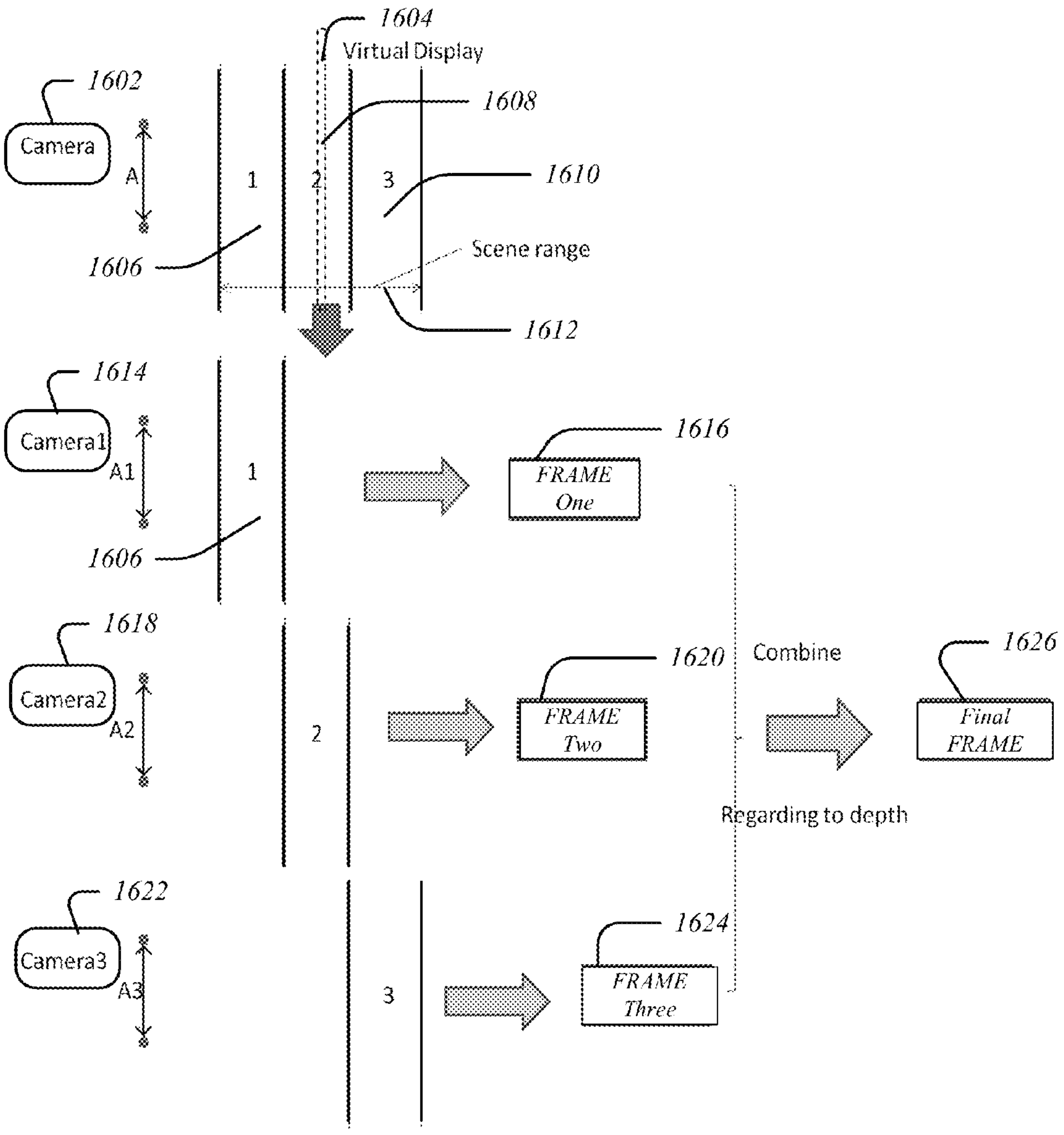

1604
Virtual Display
1602
Camera
A
1
2
3
1608
1610
1606
Scene range
1612
1614
Camera1
A1
1
1616
FRAME One
1606
1618
Camera2
A2
2
1620
FRAME Two
Combine
1626
Final FRAME
Regarding to depth
1622
Camera3
A3
3
1624
FRAME Three

FIG. 16

FIG. 17

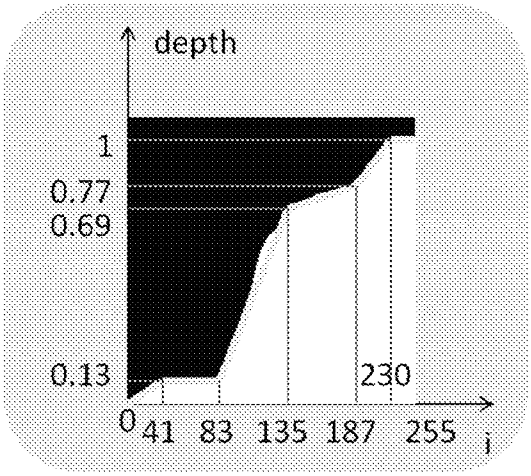

depth
1
0.77
0.69
0.13
0
41
83
135
187
230
255
i

FIG. 18

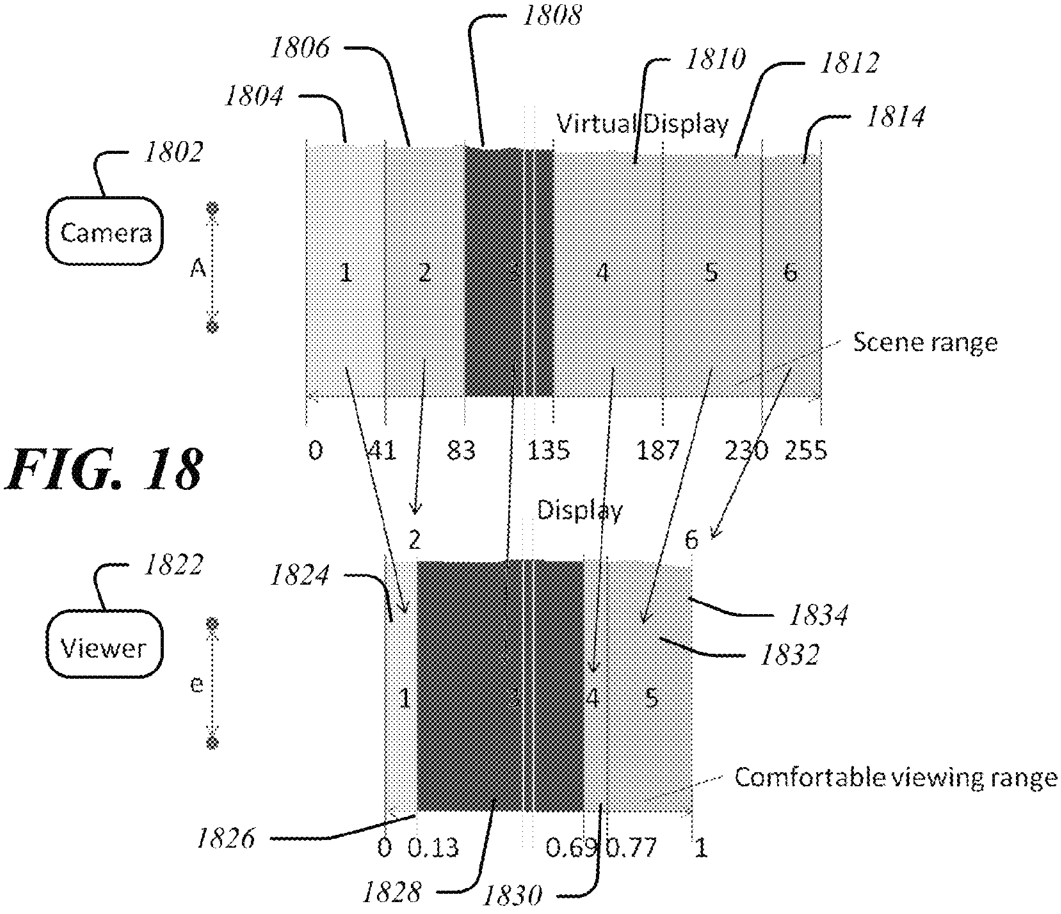

1808
1806
1810
1812
1804
Virtual Display
1814
1802
Camera
A
1
2
3
4
5
6
Scene range
0
41
83
135
187
230
255
Display
2
6
1822
1824
1834
Viewer
1832
e
1
3
4
5
Comfortable viewing range
1826
0
0.13
0.69
0.77
1
1828
1830

FIG. 19

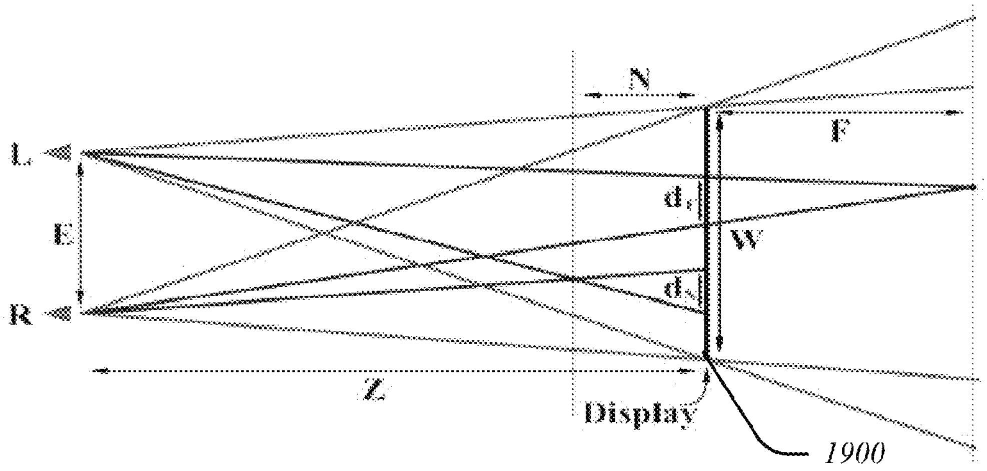


FIG. 20

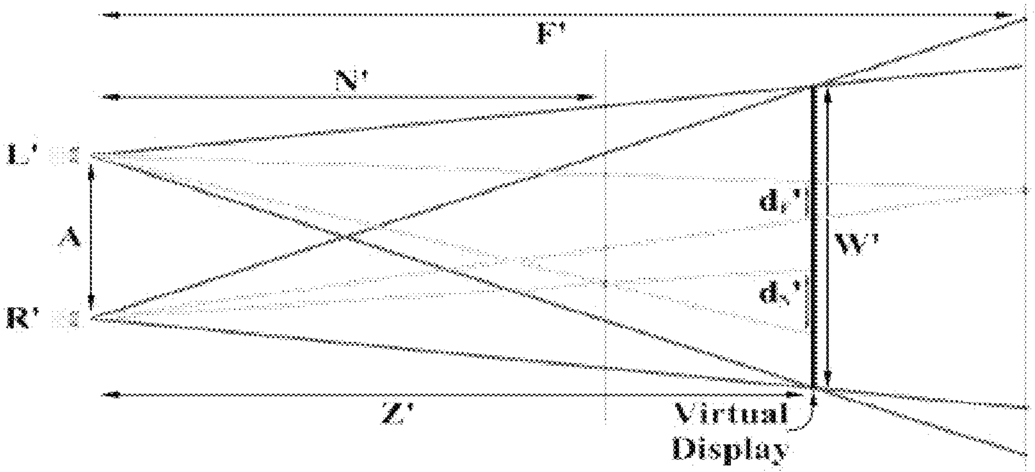


FIG. 21

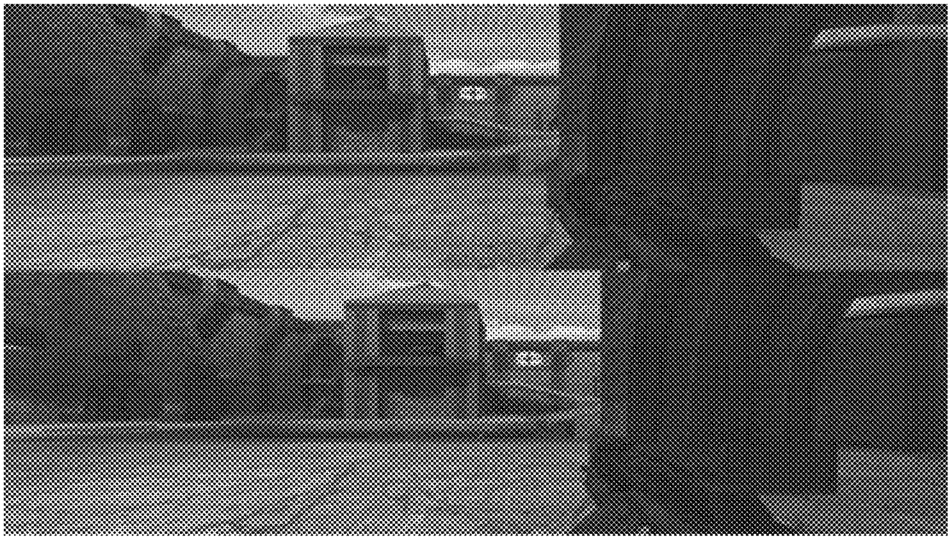
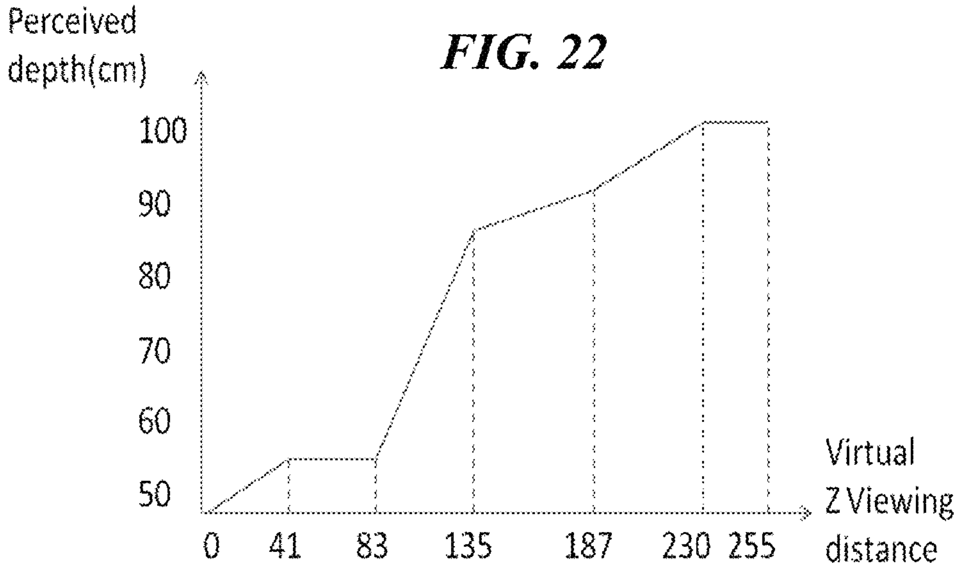


FIG. 22


Perceived depth(cm)
100
90
80
70
60
50
0
41
83
135
187
230
255
Virtual Z Viewing distance

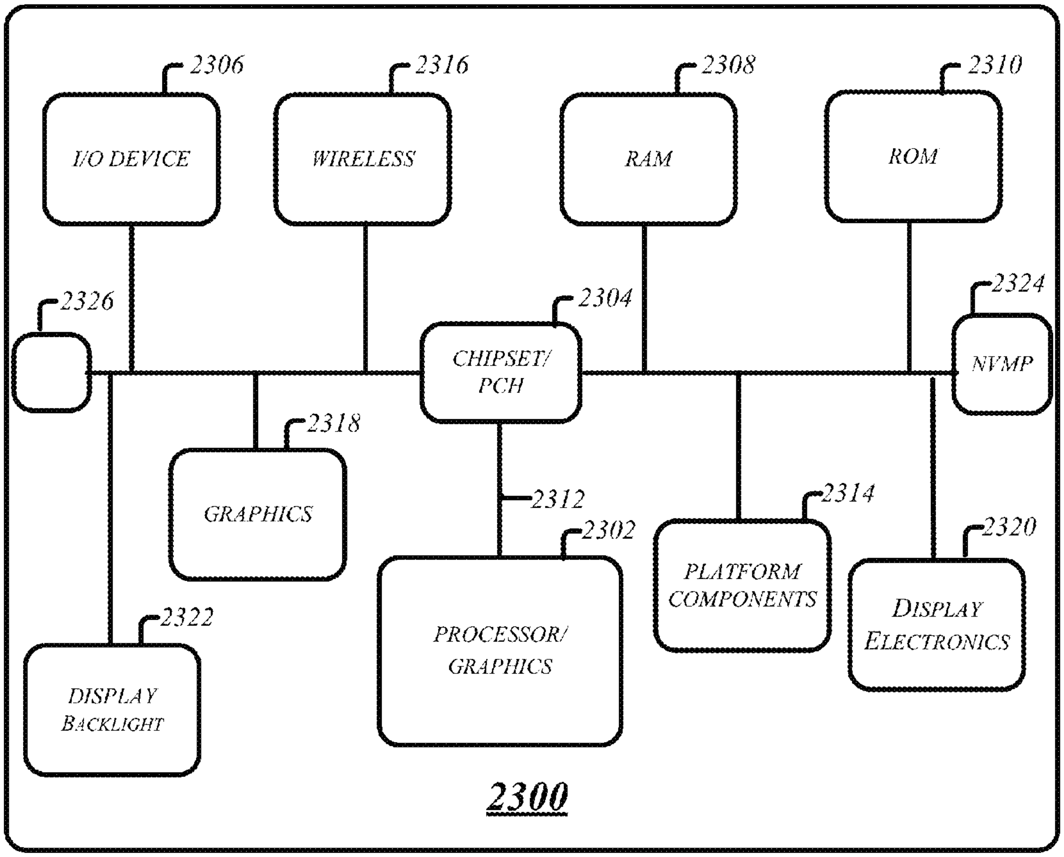

2306
I/O DEVICE
2316
WIRELESS
2308
RAM
2310
ROM
2326
2304
CHIPSET/
PCH
2324
NVMP
2318
GRAPHICS
2312
2314
PLATFORM
COMPONENTS
2302
PROCESSOR/
GRAPHICS
2320
DISPLAY
ELECTRONICS
2322
DISPLAY
BACKLIGHT
2300

FIG. 23

TECHNIQUES FOR STEREO THREE DIMENSIONAL IMAGE MAPPING

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Ser. No. 61/829,723, filed May 31, 2013 the entirety of which is hereby incorporated by reference.

BACKGROUND

Three-dimensional (3D) gaming is becoming increasingly popular. As with other types of multimedia content, one design goal for 3D games is to allow uninterrupted operation across a wide range of electronic devices, such as personal computer, tablet computer and smart phone. 3D gaming across different devices, however, remains a challenge due to a number of factors, not the least of which is that viewers have limited depth perception. If a viewer's perceived scene is outside of a comfortable viewing range, the viewer may experience eyestrain or other physical discomfort. A comfortable viewing range is dependent, at least in part, on screen size. Therefore, playing a 3D game across different devices with different screen sizes remains a design challenge not answered by conventional cross-platform solutions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts one embodiment of a system for mapping of S3D content to multiple different devices.

FIG. **2** depicts a further embodiment of a system in which a server generates one base code for S3D content to be deployed on multiple different devices.

FIG. **3**A illustrates general features of the geometry for properly viewing a display.

FIGS. **3**B and **3**C illustrate details of the geometry for the situations in which an object appears in front of and behind the display, respectively.

FIG. **4** illustrates a scenario when Z viewing distance is linearly compressed so that the perceived depth is less than the Z viewing distance.

FIG. **5**A illustrates the geometry of objects that are positioned with respect to a camera.

FIG. **5**B shows a scenario in which objects are presented on a display so as to fall within and outside of comfortable area.

FIG. **5**C illustrates the effects of linear compression so that objects all fall within a comfortable range.

FIG. **6** presents an exemplary result of interest aware disparity mapping consistent with the present embodiments in which undistorted objects are located within a comfortable range.

FIG. **7** illustrates one communications architecture according to some embodiments in which a sending device is a wireless device such as a user tablet.

FIG. **8** illustrates another communications architecture according to other embodiments in which a sending device is a server that includes one code base for a given S3D game.

FIG. **9** depicts an exemplary logic flow.

FIG. **10** illustrates exemplary geometry showing parameters relevant to analysis of screen size and expected viewer distance.

FIG. **11**A provides an exemplary RGB frame.

FIG. **11**B presents a related depth frame generated for the frame corresponding to the RGB frame of FIG. **11**A.

FIGS. **12**A and **12**B show one exemplary implementation in which conventional Roberts kernels are chosen to perform edge detection.

FIG. **13** presents a depth edge frame (diagram) derived from the process of FIGS. **12**A and **12**B.

FIG. **14** presents an example graph (grayscale diagram).

FIG. **15** presents an exemplary depth distribution diagram.

FIG. **16** depicts an example in which a camera is to capture a depth range.

FIG. **17** presents one example of the results of a division process.

FIG. **18** depicts the relationship between camera space and viewer space following the example of FIG. **17**.

FIGS. **19** and **20** present an example for mapping each of different camera region

using a method for controlling perceived depth in stereoscopic images.

FIG. **21** presents left and right images based upon the image of FIG. **11**A.

FIG. **22** presents a graph of perceived depth as a function of virtual viewing distance for the scene of FIG. **21**.

FIG. **23** presents an exemplary system embodiment.

DETAILED DESCRIPTION

Embodiments provide enhancements to sharing and viewing of stereoscopic 3D (S3D, or simply "3D') content among digital display devices in which screen size, among other properties, may vary. The embodiments provide an enhanced usage model of a computing continuum in which a target device configuration to display 3D content is obtained before 3D content sharing is performed. The present embodiments in particular present techniques that may be performed in real-time to perform disparity mapping and are referred to herein as "interest aware disparity mapping" operations or algorithms.

By way of background, three dimensional (3D) television (TV) is widely used for watching stereo (or stereoscopic) 3D (S3D) movies and TV programs. However, there are as yet few S3D games in use. One reason for this may include costs of purchasing a S3D monitor for playing games on a personal computer (PC) or a S3D mobile device to play S3D mobile games.

With the ubiquitous deployment and interconnectivity of computing and communications devices and the development of a computer continuum, technical content is readily shared across multiple different devices. In contrast, usage models are lacking for playing and deploying stereo 3D games across different devices. In some scenarios, for example, it may be more convenient for users to use mobile phones or tablet devices as input to play stereo games on a large television (TV) screen or PC monitor. Moreover, for game developers, it is convenient to maintain a single code base that can perform well on different digital displays (screens) having different screen sizes.

Due to the lack of consideration in adapting use of stereo 3D displays for the computer continuum, stereo 3D depth mapping for different devices has been wholly ignored. Typically, S3D game development is done in a manner in which a computer game/video is designed for a dedicated device without consideration of deployment of the game on different digital displays in which the screen size may vary. Moreover, stereo game developers often produce only one code base for stereo 3D disparity, which is designed for a dedicated device.

One problem with this approach arises from the fact that for a given stereo 3D display, viewers have limited depth perception. If a scene being presented appears outside of a comfortable range, the viewer may experience eyestrain or other discomfort. In turn, this comfortable viewing range, or comfortable range, has a strong relationship with screen size in which the scene is viewed. In a stereo 3D display, depth is perceived by disparities that are introduced between respective images perceived by right and left eyes. In current stereo 3D games, the disparities are always adjusted for a dedicated device, resulting in a constant disparity value for a given game. However, because different digital display devices have different screen sizes and different comfortable viewing ranges, it may be uncomfortable for an end user to play a stereo 3D game on another device that does not have a similar screen size to a target screen size for which the stereo 3D game was developed.

One way to address this issue is to compress a 3D scene from game space to real display space such that the entire 3D scene is within the comfortable range. In conventional approaches, linear depth retargeting is used to perform this change, because it is easy to implement. However, if the ratio of width and depth in virtual space is different from the original ratio of the content, which is universally the case, the content in each frame has to be compressed to meet a comfortable stereo 3D range. However using linear depth mapping algorithms to compress the most important part of the content in each frame typically will cause content distortion resulting in a poor user experience for end users viewing the compressed frame.

Embodiments of the disclosure attempt to solve these and other problems. Embodiments may implement various interest aware disparity mapping operations or algorithms that allow a 3D game to be shared across multiple electronic devices in a seamless and user friendly manner.

FIG. **1** depicts one embodiment of a system **100** for mapping of S3D content to multiple different devices. In the example illustrated, the tablet device **102** sends disparity mapped S3D frames to a 3D projector **104**, a 3D monitor **106** and 3D TV **108**. As detailed below, each different device may be sent a different S3D content based upon the screen size and expected viewing distance of a viewer.

FIG. **2** depicts a further embodiment of a system **200** in which a server **202** generates one base code for S3D content such as a video game to be deployed on multiple different devices having different screen sizes. In the embodiment of FIG. **2** the system **200** is a "cloud" based system in which the server **202** is located in any convenient location of a network such as the Internet. The various devices including tablet device **204**, laptop **206**, stereo TV **208**, and smartphone **210** link via a network or combination of networks to the server **202**, which may be remote from the devices. S3D content is provided in a format that is tailored for viewing without eyestrain by a viewer of each device **204**,**206**,**208**, **210**, and in a manner that preserves depth information for important or interesting objects or content being viewed.

FIGS. **3**A to **6** below illustrate various principles and functions that aid in explanation of operation of the present embodiments. In particular, FIG. **3**A illustrates general features of the geometry for properly viewing a display. The perspective in FIG. **3**A is a top down view illustrating the position of viewer's eyes **302**, **304** with respect to the display **306**. The region **308** represents a comfortable viewing region or zone in which objects that appear to be within the comfortable viewing region **308** do not create undue discomfort to the viewer. As illustrated, the comfortable viewing region **308** extends both in front of and behind the position of the display **306**.

FIGS. **3**B and **3**C illustrate details of the geometry for the situations in which an object appears in front of and behind the display **306**, respectively. In FIG. **3**B, e is the distance between the viewer's eyes, d is the disparity (separation) on the screen for the same object, h is the perceived depth, and N is the expected distance between the viewer and screen. In FIG. **3**B, according to similar triangles d/e=h−N/h. In other words, h=eN/e−d. In FIG. **3**C, d/e=N−h/h such that h=eN/e+d. Since e is constant for a given viewer and N is constant for a given display screen, once the disparity d is decided, the perceived depth is determined and a comfortable range **308** may be defined as detailed further below.

In conventional stereo 3D games, the disparities d are adjusted for dedicated devices and are a constant value. However, different screens (digital displays) have different screen sizes and different comfortable viewing ranges. Therefore it is often uncomfortable for end users to play a given S3D game in a device that may not have a similar screen size with that for which the given S3D game was designed by the game designers.

One way to address this issue is to compress 3D scene from game space to real display space and make sure all the scene is within the comfortable range. FIG. **4** illustrates that the Z viewing distance is linearly compressed so that the perceived depth is less than the Z viewing distance. FIG. **5**A illustrates the geometry of objects that are positioned with respect to a camera **502**. In particular, the objects **504**, **506**, and **508** are 3D objects that are located at various depths within a virtual range **510**.

FIG. **5**B shows a scenario in which the objects **504**, **506**, **508** are presented on the display **520** and fall within the display range **514** as follows: the objects **506**, **508** fall within comfortable area **516**, while the object **504** falls within the constrained range **504**. Thus, the viewer **512** may experience eye strain in viewing presentation of the objects **504**, **506**, **508**.

In accordance with conventional approaches a so-called linear depth retargeting may be performed to compress the range within which objects **504**, **506**, **508** fall when presented upon the display **520**. Thus, as shown in FIG. **5**C, the compressed objects **524**, **526**, **528** all fall within comfortable range **522**. However, the objects **504**, **506**, **508** may appear distorted as shown, thereby degrading the user experience. Moreover, due to variation in screen size and expected viewer distance, often the disparity should be adjusted to accommodate different target devices to display an S3D presentation such as a S3D game.

The present embodiments may address these issues by performing a method and framework for depth retargeting, which, is accomplished, for S3D displays by disparity mapping. This procedure is referred to herein as "interest aware disparity mapping." The present embodiments provide specific operations to accomplish interest aware disparity mapping as well as architecture for implementing the interest aware disparity mapping. The present embodiments provide a realistic way to enhance user experience when playing stereo 3D games, which creates a new usage model for the computer continuum.

Following the example of FIGS. **5**A-**5**C, FIG. **6** presents an exemplary result of interest aware disparity mapping in which the undistorted objects **604**, **606**, **608** are located within the comfortable range **522**. This result provides an enhanced user experience by preserving the appearance of important objects within an S3D scene while adjusting their location to fall within an acceptable viewing range that is adjusted for the size of display **610** and expected viewing distance of viewer **612**.

In accordance with various embodiments, the interest aware disparity mapping may be conducted from any source device to other target devices that have displays to present S3D content. In accordance with the present embodiments, content senders, which may be termed a "source device," may first obtain receiving device information such as screen size, expected viewer distance, and other related information. Subsequently, the source device performs interest aware disparity mapping to produce disparity mapped frames according to a given target device configuration. The source device subsequently transmits the interest-aware-disparity-mapped frames to the receiving device, or "target device," with more appropriate image/game frame structure to reduce view distortion in comparison to conventional disparity mapping.

The interest aware disparity mapping operations of the present embodiments are effective to prevent viewing distortion brought about by unsuitable depth mapping, when the screen size or viewer distance is different between source video and target device. The operations according to some embodiments are designed to cause minimal change to important content of an S3D frame while performing the appropriate depth retargeting when playing stereo 3D content in different devices.

FIG. **7** illustrates one communications architecture **700** according to some embodiments in which a source device or "sending device" **702** is a wireless device such as a user tablet. The sending device **702** is capable of wireless communications with various other devices such that the sending device **702** can wirelessly obtain device information about other devices and wirelessly transmit S3D content to those other devices. In the communications architecture **700** the sending device **702** receives wireless messages **720**, **722**, and **724** which include device information for 3D monitor **710**, 3D projector **712**, and 3D TV **714**, respectively.

The sending device **702** is equipped with an interest aware disparity mapping component **708** that performs disparity mapping according to the device information received, which information may include screen size and/or expected viewing distance as example device information. A processor **703** may retrieve a source S3D frame **704** of an S3D video (not shown) for mapping to one or more different receiving devices (target devices). As detailed below, the interest aware disparity mapping component **708** processes each source S3D frame **704** to generate a disparity mapped frame **706** for each receiving device, which disparity mapped frame may differ among the 3D monitor **710**, 3D projector **712**, and 3D TV **714**. As illustrated, the respective disparity mapped frames **706** are sent via respective messages **730**, **732**, **734** to 3D monitor **710**, 3D projector **712**, and 3D TV **714**. The S3D procedures generally outlined in FIG. **7** may be performed in real-time such that disparity mapping for a target device is carried out when S3D content is to be sent to that target device. Notably, the disparity map frame **706** may vary for each receiving device, such as the 3D monitor **710**, 3D projector **712**, and 3D TV **714**.

FIG. **8** illustrates another communications architecture **800** according to other embodiments in which a sending device is a server **802** that includes one code base for a given S3D game. It is to be noted that in the present embodiments a source device may have a communications interface for sending and receiving information to and from a target device via wireless transmission, wired transmission, or a combination or wired and wireless transmission. The communications architecture **800** is a cloud based architecture in which the server **802** is communicatively linked with various other devices over one or more networks that may include wired links, wireless links, or a combination of the two (not shown). The server **802** may perform interest aware disparity mapping to provide S3D frames that are tailored to the receiving device such as the tablet **804**, laptop device **806**, desktop device/3D monitor **808**, or smartphone **810**. As with the scenario of FIG. **7**, the disparity mapping may be carried out in real time.

FIG. **9** depicts an exemplary logic flow **900**. The exemplary logic flow **900** presents features of interest aware disparity mapping according to embodiments of the disclosure. The FIGS. **10** to **22** and appurtenant text to follow present details of implementation of the logic flow consistent with various embodiments. The logic flow **900** may be used by a source device to prepare S3D frames for presentation on a target device. The source device and target device may be located proximate one another or remote from one another in different embodiments as discussed above with respect to FIGS. **7** and **8**.

At block **902**, screen size and expected viewing distance is analyzed for a target device. This analysis may be based upon device information received from the target device. The target device information may be sent in a message from the target device to a source device in one example.

At block **904** a frame is captured from a digital game. In various embodiments the digital game is an S3D game. The frame may be captured as a color image frame (RGB frame) **904**A and a depth frame **904**B. A depth frame may be set of depth values that presented as a function of position within a frame, and may therefore map onto corresponding RGB information in an RGB frame. The depth frame may be calculated in real-time after an RGB frame is loaded in some embodiments.

At block **906** edge detection is performed for a depth frame (diagram) to produce a depth edge diagram. At block **908**, a gray scale is obtained for the depth diagram with the aid of the depth edge diagram. At block **910** a smoothening of the grayscale diagram is performed. At block **912**, a depth distribution diagram is generated. At block **914** a depth region is divided into different depth (camera) regions for different cameras. At block **916**, a camera parameter is generated for each camera region is generated. At block **918**, camera views with different depth regions are added together. Details of exemplary implementation of the logic flow **900** are set forth in the figures to follow.

FIG. **10** illustrates exemplary geometry showing parameters relevant to analysis of screen size and expected viewer distance. When viewing stereo 3D, users whose eyes **1002** and **1004** are shown, may experience a comfortable perceived depth with respect to the screen **1006** as shown. In particular, N is the acceptable distance in front of the display **1006** and F is the acceptable distance behind (inside) the display **1006**. The parameter W represents the screen width. In some examples, N is 0.4 W and F is 0.7 W. Accordingly, knowledge of W may generate directly the calculation of acceptable distances N and F.

Regarding block **904**A and **904**B, FIG. **11**A provides an exemplary RGB frame **1100**, which may be captured from a back buffer that stores an S3D frame. FIG. **11**B presents a related depth frame **1110** generated for the same S3D frame. In FIG. **11**B, the lighter the image portion, the more remote in depth the objects presented in that image portion are located. Thus, the depth frame **1110** presents a two dimensional representation of depth information as a function of pixel position for objects in an S3D frame.

Regarding block **906**, it is noted that users recognize objects by their edge, which may distinguish the border of a given object from other objects. The same situation may apply to depth recognition. Accordingly, in the present embodiments, after formation or receipt of a depth frame for a given S3D frame, edge detection is performed on the depth frame, such as the depth frame **1110** of FIG. **11**B. This edge detection may be carried out in various manners. In one exemplary implementation, conventional Roberts kernels are chosen to perform edge detection as shown in the exemplary kernels, which represent one known method for distinguishing pixels from neighbors. This is shown for Roberts kernels **1202** and **1204** shown in respective FIGS. **12**A and **12**B.

FIG. **13** presents a depth edge frame (diagram) **1300** derived from such a process. A depth gradient can be seen in the FIG. **13** where lighter regions or contours indicate relatively greater depth changes. Thus, light contours may appear in regions where objects of different depths are located next to one another in the depth frame **1110**. The darker regions are equivalent to little or no depth changes as a function of position in the depth frame **1110**.

Regarding block **908**, a grayscale diagram of the depth diagram may be obtained in the following manner. The number of pixels having the same depth value in a depth frame such as depth frame **1110** are summed to s_i while the depth edge frame **1300** is used as a filter. In particular, a function f(x,y) is defined as the pixel value of a pixel located at row x, column y in a depth frame such as depth frame **1110** shown in FIG. **11**B. A function u(x,y) is defined to be a pixel value of a pixel located at row x, column y in a depth edge frame such as depth edge frame **1300** shown in FIG. **13**. Additionally, a function g(i,x,y) is defined to identify how much the depth changes at a given depth i. This is done by adding up individual g values calculated for all pixels corresponding to a given depth using the function u(x,y) to determine the value at any pixel given by x,y. More particularly,

$$g(i,x,y) = \begin{cases} 1 & (\text{if } f(x,y) = i \text{ and } u(x,y) > 0) \\ 0 & (\text{otherwise}) \end{cases}. \tag{1}$$

In this manner, the summing is performed according to

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i,x,y)). \tag{2}$$

Thus, each x,y pixel position is associated with a depth value i and a g value, which may be set as “1” or “0” as defined by the operations in Eq. (1). The sum of all g values may then be determined for each depth value i.

FIG. **14** presents an example graph or grayscale diagram that is determined according to Eq. (2) in which i is the depth value from a depth frame and s_i is the sum of all g values for all pixels having depth i. As can be seen, at certain depth ranges (i) the value of s_i is zero, indicating that depth is not varying significantly in these ranges.

Regarding block **910**, grayscale smoothening may be provided by calculating a weight w_i of a grayscale diagram. In particular w_i is a weight of depth i in a source frame that is given $w_i = s_i/s$ where s_i is the sum of pixels with depth i and s is sum of pixels in the grayscale diagram, that is,

$$s = \sum_{i=0}^{255} s_i. \tag{3}$$

Regarding block **912**, once a weighted distribution w_i is calculated, a depth distribution diagram is generated that represents retargeted depth over a comfortable viewing range. FIG. **15** presents an exemplary depth distribution diagram **1500** that may be generated in the following manner:

$$\text{depth}_i = \text{comfortable}_{range} \times \sum_{j=0}^{i} w_i + \text{nearest}, \tag{4}$$

where depth_i is a retargeted depth in screen space for a given virtual depth value i in camera space, $\text{comfortable}_{range}$ is the range for comfortable view, and nearest is the nearest comfortable depth needed in screen space. Thus, in the example of FIG. **15**, the depth_i values are illustrated as a function of i values from the depth frame **1110**. In FIG. **15**, N is nearest comfortable perceived depth and F is farthest perceived comfortable depth, while i is virtual depth value. Thus, Eq. 4 can be rewritten as

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N. \tag{4A}$$

Regarding block **914**, different regions corresponding to different depths are defined. In order to maintain frame quality for different depth mapping, different camera pairs are used. FIG. **16** depicts an example in which a camera **1602** is to capture a depth range **1612**. For purposes of illustration, the depth range is shown in FIG. **16** as divided into three regions **1606**, **1608**, and **1610**, where region **1608** spans the position of virtual display **1604**. In order to generate the desired 3D content consistent with the present embodiments, the camera **1602** is divided into camera1 **1614**, camera2 **1618**, and camera3 **1622**, where camera1 **1614** treats region **1606**, camera2 **1616** treats region **1608**, and camera3 **1618** treats region **1610**, producing the respective frames **1616**, **1620** and **1624**. These are combined to form the final frame **1626**.

Consistent with various embodiments a recursion algorithm may be employed to define different depth regions in the following manner. As a first estimate, the range of i is divided into two parts: [0,i] and [i,255], where i is the point in which a parameter ∂ is maximized, where

$$\partial = \max\left|\frac{w_i - 0}{i - 0} - \frac{w_{255} - w_i}{255 - i}\right| \quad (i = 1, \ldots 255). \tag{5}$$

Subsequently, a recursion is performed in [0,i] and [i,255] until the parameter $\partial < \alpha$. The quantity “a” represents an experimental value that is 0.1 in some embodiments. Thus, when the value of ∂ is below a threshold, a given range is no longer divided.

FIG. **17** presents one example of the results of the division process for the procedure of Eq. (5) using the depth distribution diagram of FIG. **15**, where the number in the depth axis represents a percentage or fraction of a comfortable viewing range (comfortable$_{range}$) and i is the virtual depth value from the depth frame **1110**. It can be seen from FIG. **17** that 6 regions are formed, which are defined by respective pairs [0,41], [41,83], [83,135], [135,187], [187,230], and [230,255].

FIG. **18** depicts the relationship between camera space and viewer space following the example of FIG. **17**. As shown therein, the six depth regions **804**, **806**, **808**, **810**, **812**, and **814** of camera space map into respective mapped regions **824**, **826**, **828**, **830**, **832**, and **834** as presented to the viewer **822**, when viewing an S3D game on a target device.

Regarding block **916**, to generate a multi-step camera view, camera calculations are performed for different regions. In particular, a camera pair 1 is calculated for region 1 **1804**, camera pair 2 for region 2 **1806**, camera pair 3 for region 3 **1808**, camera pair 4 for region 4 **1810**, camera pair 5 for region 5 **1812**, and camera pair 6 for region 6 **1814**. In the present embodiments for mapping each region, the method for controlling perceived depth in stereoscopic images taught by Graham Jones's may be used. Jones's method defines the relationship between the parameters in viewer space and scene space, as illustrated in respective FIGS. **19** and **20**. FIG. **19** shows the relation of a viewers left and right eyes L and R in relation to a display **1900** and the N and F parameters defined above. In particular, this method can perform linear mapping from [N',F'] in FIG. **20** to [Z−N, Z+F] in FIG. **19**.

Regarding block **918** camera views for different depths may be combined after views from different regions are obtained. Let L_1, L_2, L_3, L_4, L_5, L_6 represent the left view and R_1, R_2, R_3, R_4, R_5, R_6 represent the right views in regions [0,41], [41,83], [83,135], [135,187], [187,230][230, 255]. To form the left view, L_1, L_2, L_3, L_4, L_5, L_6 are combined into L for Left View for the given frame, and R_1, R_2, R_3, R_4, R_5, R_6 into R for the right view. A result of these combination operations is shown in FIG. **21**, which presents left and right images based upon the image **1100** of FIG. **11**A. In addition, FIG. **22** presents a graph of perceived depth as a function of virtual viewing distance for the scene of FIG. **21**. It can be seen that virtual z viewing distance (virtual depth) for the range [83,135] is much larger in perceived depth while the virtual z viewing distances for the ranges [41,83] and [230, 250] occupy almost zero range in perceived depth. Compared with conventional linear depth retargeting results the depth information in the range [83, 135] is much more preserved in its original form, while other virtual depth ranges are compressed. This result exemplifies the ability of the present embodiments to emphasize a virtual depth range, such as [83, 135], which may be the most important range to end users because of content contained therein.

FIG. **23** is a diagram of an exemplary system embodiment and in particular, FIG. **23** is a diagram showing a system **2300**, which may include various elements. For instance, FIG. **23** shows that system (platform) **2300** may include a processor/graphics core, termed herein processor **2302**, a chipset/platform control hub (PCH), termed herein chipset **2304**, an input/output (I/O) device **2306**, a random access memory (RAM) (such as dynamic RAM (DRAM)) **2308**, and a read only memory (ROM) **2310**, display electronics **2320**, display backlight **2322**, and various other platform components **2314** (e.g., a fan, a crossflow blower, a heat sink, DTM system, cooling system, housing, vents, and so forth). System **2300** may also include wireless communications chip **2316** and graphics device **2318**, non-volatile memory port (NVMP) **2324**, and antenna **2326**. The embodiments, however, are not limited to these elements.

As shown in FIG. **23**, I/O device **2306**, RAM **2308**, and ROM **2310** are coupled to processor **2302** by way of chipset **2304**. Chipset **2304** may be coupled to processor **2302** by a bus **2312**. Accordingly, bus **2312** may include multiple lines.

Processor **2302** may be a central processing unit comprising one or more processor cores and may include any number of processors having any number of processor cores. The processor **2302** may include any type of processing unit, such as, for example, CPU, multi-processing unit, a reduced instruction set computer (RISC), a processor that have a pipeline, a complex instruction set computer (CISC), digital signal processor (DSP), and so forth. In some embodiments, processor **2302** may be multiple separate processors located on separate integrated circuit chips. In soME Embodiments processor **2302** may be a processor having integrated graphics, while in other embodiments processor **2302** may be a graphics core or cores. Commands can be provided to processor **2302**, for example, through keyboard, TOuch screen interaction, gestures, facial expressions, and sounds.

In summary, the present embodiments provide enhanced usage models of the computing continuum which provide for the ability to obtain target device configuration for 3D content sharing. In particular, the real-time interest aware disparity mapping methods provide a novel implementation for S3D sharing. In comparison to linear disparity mapping conventionally used in real-time depth retargeting, the present embodiments are based on content analysis results for depth retargeting.

The methods of the present embodiments in particular facilitate selection of a morE IMportant depth range(s) that is to be less altered for presentation in a user device in comparison to other depth ranges. Final depth retargeting results in the generation of a series of virtual depth ranges in which percelVED depth varies with virtual depth (viewing range) in different fashion among the different virtual depth ranges. This leads to generation of select virtual depth ranges in which objects or other content are expanded or less compressed in perceived depth aS OPposed to objects or content in other virtual depth ranges, thereby allowing an entire scene of a S3D frame to be presented on a user screen within a comfortable viewing range without unduly altering important content of the S3D frame.

The following examples pertain to further embodiments.

In example 1, an apparatus for mapping a stereo three dimensional game may include a processor to retrieve a stereo three dimensional (S3D) frame of an S3D game, the frame comprising a red-green-blue (RGB) frame and depth frame; and an interest aware disparity mapping component to: generate a depth edge frame from the depth frame and to generate a depth distribution diagram for the depth frame based on the depth edge frame, the depth distribution diagram defining a multiplicity of camera regions for generating a mapped S3D frame for a target device based upon viewing parameters of the target device.

In example 2, the viewing parameters of the target device of example 1 may include screen size and expected viewing distance for the target device.

In example 3, the depth frame of any of examples 1-2 may comprise a two dimensional representation of depth information as a function of pixel position for objects depicted in the S3D frame.

In example 4, the depth edge frame of any of examples 1-3 may comprise a set of pixels (x,y) and values u(x,y) where u(x,y) is proportional to a change in depth in pixels adjacent to pixel (x,y).

In example 5 the interest aware disparity mapping component of any of examples 1-4 may be to generate a grayscale diagram comprising depth change information from the depth frame, the grayscale diagram comprising s_i as a function of depth i, where

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i, x, y)) \text{ and where}$$

$$(g(i, x, y)) = \begin{cases} 1 & (\text{if } f(x, y) = i \text{ and } u(x, y) > 0) \\ 0 & (\text{others}) \end{cases}.$$

In example 6 the depth distribution diagram of any of examples 1-5 may comprise a retargeted depth in screen space of the target device, depth_i as a function of i, where

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N$$

where N and F are nearest comfortable perceived depth and furthest comfortable perceived depth for the target device, and w_i is a weighted average of s_i.

In example 7 the interest aware disparity mapping component of any of examples 1-6 may be to determine the multiplicity of camera regions by applying a recursion process to the depth distribution diagram.

In example 8 the interest aware disparity mapping component of any of examples 1-7 may be to calculate a camera parameter for each of the multiplicity of camera regions.

In example 9 the interest aware disparity mapping component of any of examples 1-8 may be to generate a mapped left frame L and right frame R for presentation of the S3D frame on the target device, where L and R are a sum of respective left camera views and right camera views of the multiplicity of camera regions.

In example 10, the apparatus of any of examples 1-9 may include a display to present the S3D video, a network interface and radio.

In example 11, at least one machine-readable storage medium includes instructions that when executed by a computing device, cause the computing device to: receive viewing parameters of a target device; retrieve a stereo three dimensional (S3D) frame of an S3D game comprising a red-green-blue (RGB) frame and depth frame; generate a depth edge frame from the depth frame; and generate a depth distribution diagram for the depth frame based on the depth edge frame, the depth distribution diagram defining a multiplicity of camera regions for generating a mapped S3D frame for a target device based upon viewing parameters of the target device.

In example 12, the viewing parameters of the target device of the at least one machine-readable storage medium of example 11 may include screen size and expected viewing distance for the target device.

In example 13, the depth frame of any of examples 11-12 may include a two dimensional representation of depth information as a function of pixel position for objects depicted in the S3D frame.

In example 14, the depth edge frame of any of examples 11-13 may include a set of pixels (x,y) and values u(x,y) where u(x,y) is proportional to a change in depth in pixels adjacent to pixel (x,y).

In example 15, the at least one machine-readable storage medium of any of examples 11-14, may comprise instructions that when executed by a computing device, cause the computing device to: generate a grayscale diagram comprising depth change information from the depth frame, the grayscale diagram comprising s_i as a function of depth i, where

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i, x, y)) \text{ and where}$$

$$(g(i, x, y)) = \begin{cases} 1 & (\text{if } f(x, y) = i \text{ and } u(x, y) > 0) \\ 0 & (\text{others}) \end{cases}.$$

In example 16, the depth distribution diagram of any of examples 11-15 may include a retargeted depth in screen space of the target device, depth_i as a function of i, where

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N$$

where N and F are nearest comfortable perceived depth and furthest comfortable perceived depth for the target device, and w_i is a weighted average of s_i.

In example 17, the at least one machine-readable storage medium of any of examples 11-16, may comprise instructions that when executed by a computing device, cause the computing device to determine the multiplicity of camera regions by applying a recursion process to the depth distribution diagram.

In example 18, the at least one machine-readable storage medium of any of examples 11-17, may comprise instructions that when executed by a computing device, cause the computing device to calculate a camera parameter for each of the multiplicity of camera regions.

In example 19, the at least one machine-readable storage medium of any of examples 11-18, may comprise instructions that when executed by a computing device, cause the computing device to generate a mapped left frame L and right frame R for presentation of the S3D frame on the target device, where L and R are a sum of respective left camera views and right camera views of the multiplicity of camera regions.

In example 20, a computer implemented method for mapping a stereo three dimensional game may include: receiving viewing parameters of a target device; retrieving a stereo three dimensional (S3D) frame of an S3D game comprising a red-green-blue (RGB) frame and depth frame; generating a depth edge frame from the depth frame; and generating a depth distribution diagram for the depth frame based on the depth edge frame, the depth distribution diagram defining a multiplicity of camera regions for generating a mapped S3D frame for a target device based upon viewing parameters of the target device.

In example 21, the viewing parameters of the target device of example 20 may include screen size and expected viewing distance for the target device, and the depth frame comprising a two dimensional representation of depth information as a function of pixel position for objects depicted in the S3D frame.

In example 22, the depth edge frame of any of examples 20-21 may include a set of pixels (x,y) and values u(x,y) where u(x,y) is proportional to a change in depth in pixels adjacent to pixel (x,y).

In example 23, the computer implemented method of any of examples 20-22 may include: generating a grayscale diagram comprising depth change information from the depth frame, the grayscale diagram comprising s_i as a function of depth i, where

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i, x, y)) \text{ and where}$$

$$(g(i, x, y)) = \begin{cases} 1 & (\text{if } f(x, y) = i \text{ and } u(x, y) > 0) \\ 0 & (\text{others}) \end{cases}.$$

In example 24, the depth distribution diagram of any of examples 20-23 may include retargeted depth in screen space of the target device, depth_i as a function of i, where

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N$$

where N and F are nearest comfortable perceived depth and furthest comfortable perceived depth for the target device, and w_i is a weighted average of s_i.

In example 25, the computer implemented method of any of examples 20-24 may include calculating a camera parameter for each of the multiplicity of camera regions.

In example 26, the computer implemented method of any of examples 20-25 may include generating a mapped left frame L and right frame R for presentation of the S3D frame on the target device, where L and R are a sum of respective left camera views and right camera views of the multiplicity of camera regions.

Example 27 is user equipment to manage I/O data comprising means to perform the method of any of examples 20-26.

Example 28 is an apparatus to manage I/O data comprising means to perform the method of any one of examples 20-26.

In example 29, at least one machine-readable storage medium includes instructions that when executed by a computing device, cause the computing device to: perform the method of any of examples 20-26.

In example 30 a device for mapping a stereo three dimensional game, includes: a processor to retrieve a stereo three dimensional (S3D) frame of an S3D game, the frame comprising a red-green-blue (RGB) frame and depth frame; a communications interface to receive viewing parameters of a target device; and an interest aware disparity mapping component to: generate a depth edge frame from the depth frame and generate a depth distribution diagram for the depth frame based on the depth edge frame, the depth distribution diagram defining a multiplicity of camera regions for generating a mapped S3D frame for the target device based upon the viewing parameters of the target device.

In example 31 the viewing parameters of the target device of example 30 may include screen size and expected viewing distance for the target device.

In example 32 the depth frame of any of examples 30-31 may include a two dimensional representation of depth information as a function of pixel position for objects depicted in the S3D frame.

In example 33, the depth edge frame of any of examples 30-32 may include a set of pixels (x,y) and values u(x,y) where u(x,y) is proportional to a change in depth in pixels adjacent to pixel (x,y).

In example 34, the interest aware disparity mapping component of any of examples 30-33 may be to generate a grayscale diagram comprising depth change information from the depth frame, the grayscale diagram comprising s_i as a function of depth i, where

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i, x, y)) \text{ and where}$$

$$(g(i, x, y)) = \begin{cases} 1 & (\text{if } f(x, y) = i \text{ and } u(x, y) > 0) \\ 0 & (\text{others}) \end{cases}.$$

In example 35, the depth distribution diagram of any of examples 30-34 may include a retargeted depth in screen space of the target device, depth_i as a function of i, where

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N$$

where N and F are nearest comfortable perceived depth and furthest comfortable perceived depth for the target device, and w_i is a weighted average of s_i.

In example 36 the interest aware disparity mapping component of any of examples 30-35 may be to determine the multiplicity of camera regions by applying a recursion process to the depth distribution diagram.

In example 37 the interest aware disparity mapping component of any of examples 30-36 may be to calculate a camera parameter for each of the multiplicity of camera regions.

In example 38 the interest aware disparity mapping component of any of examples 30-37 may be to generate a mapped left frame L and right frame R for presentation of the S3D frame on the target device, where L and R are a sum of respective left camera views and right camera views of the multiplicity of camera regions.

The embodiments, as previously described, may be implemented using various hardware elements, software elements, or a combination of both. Examples of hardware elements may include devices, logic devices, components, processors, microprocessors, circuits, processor circuits, circuit elements (e.g., transistors, resistors, capacitors, inductors, and so forth), integrated circuits, application specific integrated circuits (ASIC), programmable logic devices (PLD), digital signal processors (DSP), field programmable gate array (FPGA), memory units, logic gates, registers, semiconductor device, chips, microchips, chip sets, and so forth. Examples of software elements may include software components, programs, applications, computer programs, application programs, system programs, software development programs, machine programs, operating system software, middleware, firmware, software modules, routines, subroutines, functions, methods, procedures, software interfaces, application program interfaces (API), instruction sets, computing code, computer code, code segments, computer code segments, words, values, symbols, or any combination thereof. Determining whether an embodiment is implemented using hardware elements and/or software elements may vary in accordance with any number of factors, such as desired computational rate, power levels, heat tolerances, processing cycle budget, input data rates, output data rates, memory resources, data bus speeds and other design or performance constraints, as desired for a given implementation.

In some embodiments, an element is defined as a specific structure performing one or more operations. It may be appreciated, however, that any element defined as a specific structure performing a specific function may be expressed as a means or step for performing the specified function without the recital of structure, material, or acts in support thereof, and such means or step is meant to cover the corresponding structure, material, or acts described in the detailed description and equivalents thereof. The embodiments are not limited in this context.

Some embodiments may be described using the expression "one embodiment" or "an embodiment" along with their derivatives. These terms mean that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment. Further, some embodiments may be described using the expression "coupled" and "connected" along with their derivatives. These terms are not necessarily intended as synonyms for each other. For example, some embodiments may be described using the terms "connected" and/or "coupled" to indicate that two or more elements are in direct physical or electrical contact with each other. The term "coupled," however, may also mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other.

In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein," respectively. Moreover, the terms "first," "second," "third," and so forth, are used merely as labels, and are not intended to impose numerical requirements on their objects.

What has been described above includes examples of the disclosed architecture. It is, of course, not possible to describe every conceivable combination of components and/or methodologies, but one of ordinary skill in the art may recognize that many further combinations and permutations are possible. Accordingly, the novel architecture is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims.

What is claimed is:

1. An apparatus, comprising:

a processor to retrieve a stereo three dimensional (S3D) frame of an S3D game, the frame comprising a red-green-blue (RGB) frame and depth frame; and

an interest aware disparity mapping component to:

generate a depth edge frame from the depth frame, the depth edge frame comprising a set of pixels (x,y) and values u(x,y) where u(x,y) is proportional to a change in depth in pixels adjacent to pixel (x,y);

generate a grayscale diagram comprising depth change information from the depth frame, the grayscale diagram comprising s_i as a function of depth i, where

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i, x, y)) \text{ and where}$$

$$(g(i, x, y)) = \begin{cases} 1 & (\text{if } f(x, y) = i \text{ and } u(x, y) > 0) \\ 0 & (\text{others}) \end{cases};$$

generate a depth distribution diagram for the depth frame based on the depth edge frame; and

define a multiplicity of camera regions based on the depth distribution diagram, wherein the multiplicity of camera regions is to generate a mapped S3D frame for a target device based upon viewing parameters of the target device.

2. The apparatus of claim **1**, the viewing parameters of the target device including screen size and expected viewing distance for the target device.

3. The apparatus of claim **1**, the depth frame comprising a two dimensional representation of depth information as a function of pixel position for objects depicted in the S3D frame.

4. The apparatus of claim **1**, the depth distribution diagram comprising retargeted depth in screen space of the target device, depth_i as a function of i, where

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N$$

where N and F are nearest comfortable perceived depth and furthest comfortable perceived depth for the target device, and w_i is a weighted average of s_i.

5. The apparatus of claim **1**, the interest aware disparity mapping component to determine the multiplicity of camera regions by applying a recursion process to the depth distribution diagram.

6. The apparatus of claim **1**, the interest aware disparity mapping component to calculate a camera parameter for each of the multiplicity of camera regions.

7. The apparatus of claim **1**, the interest aware disparity mapping component to generate a mapped left frame L and right frame R for presentation of the S3D frame on the target device, where L and R are a sum of respective left camera views and right camera views of the multiplicity of camera regions.

8. The apparatus of claim **1**, comprising a display to present the S3D video, a network interface and radio.

9. At least one non-transitory machine-readable storage medium comprising instructions that when executed by a computing device, cause the computing device to:

receive viewing parameters of a target device;

retrieve a stereo three dimensional (S3D) frame of an S3D game comprising a red-green-blue (RGB) frame and depth frame;

generate a depth edge frame from the depth frame, the depth edge frame comprising a set of pixels (x,y) and values u(x,y) where u(x,y) is proportional to a change in depth in pixels adjacent to pixel (x,y);

generate a grayscale diagram comprising depth change information from the depth frame, the grayscale diagram comprising s_i as a function of depth i, where

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i, x, y)) \text{ and where}$$

$$(g(i, x, y)) = \begin{cases} 1 & (\text{if } f(x, y) = i \text{ and } u(x, y) > 0) \\ 0 & (\text{others}) \end{cases};$$

generate a depth distribution diagram for the depth frame based on the depth edge frame; and

define a multiplicity of camera regions based on the depth distribution diagram, wherein the multiplicity of camera regions is to generate a mapped S3D frame for a target device based upon viewing parameters of the target device.

10. The at least one non-transitory machine-readable storage medium of claim **9**, the viewing parameters of the target device including screen size and expected viewing distance for the target device.

11. The at least one non-transitory machine-readable storage medium of claim **9**, the depth frame comprising a two dimensional representation of depth information as a function of pixel position for objects depicted in the S3D frame.

12. The at least one non-transitory machine-readable storage medium of claim **9**, the depth distribution diagram comprising retargeted depth in screen space of the target device, depth_i as a function of i, where

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N$$

where N and F are nearest comfortable perceived depth and furthest comfortable perceived depth for the target device, and w_i is a weighted average of s_i.

13. The at least one non-transitory machine-readable storage medium of claim **9**, comprising instructions that when executed by a computing device, cause the computing device to calculate a camera parameter for each of the multiplicity of camera regions.

14. The at least one non-transitory machine-readable storage medium of claim **9**, comprising instructions that when executed by a computing device, cause the computing device to generate a mapped left frame L and right frame R for presentation of the S3D frame on the target device, where L and R are a sum of respective left camera views and right camera views of the multiplicity of camera regions.

15. A computer implemented method, comprising:

receiving viewing parameters of a target device;

retrieving a stereo three dimensional (S3D) frame of an S3D game comprising a red-green-blue (RGB) frame and depth frame;

generating a depth edge frame from the depth frame, the depth edge frame comprising a set of pixels (x,y) and values u(x,y) where u(x,y) is proportional to a change in depth in pixels adjacent to pixel (x,y);

generating a grayscale diagram comprising depth change information from the depth frame, the grayscale diagram comprising s_i as a function of depth i, where

$$s_i = \sum_{x=0}^{height} \sum_{y=0}^{width} (g(i, x, y)) \text{ and where}$$

$$(g(i, x, y)) = \begin{cases} 1 & (\text{if } f(x, y) = i \text{ and } u(x, y) > 0) \\ 0 & (\text{others}) \end{cases};$$

generating a depth distribution diagram for the depth frame based on the depth edge frame; and

defining a multiplicity of camera regions based on the depth distribution diagram, wherein the multiplicity of camera regions is to generate a mapped S3D frame for a target device based upon viewing parameters of the target device.

16. The computer implemented method of claim **15**, the viewing parameters of the target device including screen size and expected viewing distance for the target device, and the depth frame comprising a two dimensional representation of depth information as a function of pixel position for objects depicted in the S3D frame.

17. The computer implemented method of claim **15**, the depth distribution diagram comprising retargeted depth in screen space of the target device, depth_i as a function of i, where

$$\text{depth}_i = (N - F) \times \sum_{j=0}^{i} w_i + N$$

where N and F are nearest comfortable perceived depth and furthest comfortable perceived depth for the target device, and w_i is a weighted average of s_i.

18. The computer implemented method of claim **15**, comprising calculating a camera parameter for each of the multiplicity of camera regions.

19. The computer implemented method of claim **15**, comprising generating a mapped left frame L and right frame R for presentation of the S3D frame on the target device, where L and R are a sum of respective left camera views and right camera views of the multiplicity of camera regions.

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